

DOCUMENT RESUME

ED 150 784

EC 103 892

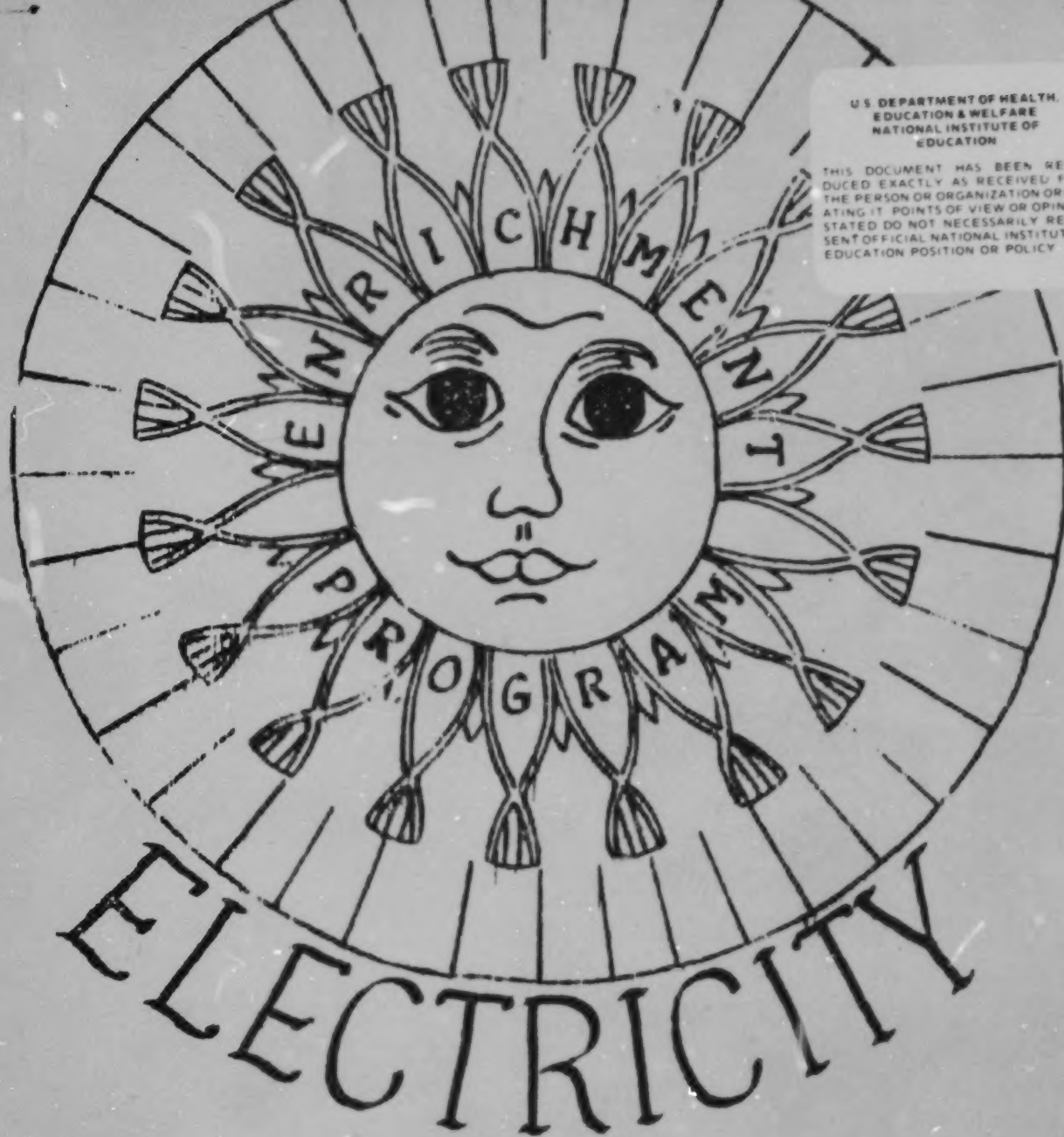
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TITLE PROJECT SUCCESS: Electricity. (Pre-post Tests, Vocabulary Lists, Beginning Circuitry, Intermediate Projects).
INSTITUTION North Kitsap School District 400, Poulsbo, Wash.
SPONS AGENCY Bureau of Elementary and Secondary Education (DHEW/OE), Washington, D.C.
PUB DATE 77
NOTE 78p.; Print on some pages is marginal and may not reproduce well in hard copy; For related information, see EC 103 889-893 and EC 103 997
AVAILABLE FROM North Kitsap School District 400, 150 High School Road South, Poulsbo, Washington 98370 (\$2.50)
EDRS PRICE MF-\$0.83 HC-\$4.67 Plus Postage.
DESCRIPTORS Academically Gifted; Class Activities; Curriculum Guides; *Electricity; Elementary Education; *Enrichment Programs; *Gifted; Science Activities; Science Instruction; Teaching Methods

ABSTRACT

Four packets comprise the electricity component of an enrichment program for gifted elementary students. Provided in the introductory packet are sample pre- and posttests for the unit. Remaining packets present vocabulary lists, student worksheets on beginning circuitry, and suggestions for student projects (such as making a battery, constructing a teaching machine, and designing an electric meter to measure the flow of electricity). (GL)

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PRE-POST TESTS

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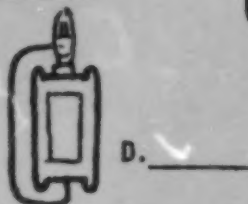
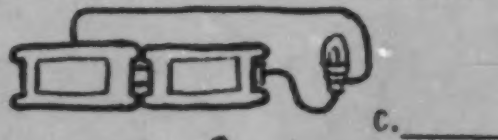
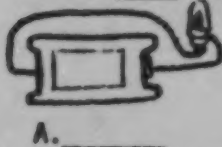
Douglas W. Strayer

TO THE EDUCATIONAL RESOURCES
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USERS OF THE ERIC SYSTEM.

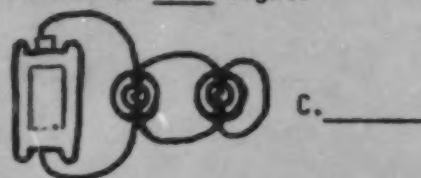
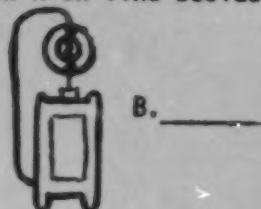
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ELECTRICITY SAMPLE TEST

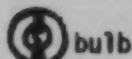
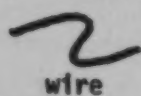
1. In which examples below will the bulb light? Mark an X on line beside those which will light.

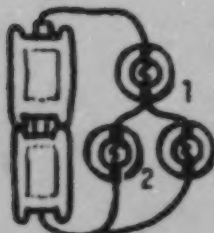


2.  is the symbol for a light bulb in a holder. In which examples below will the bulb light? Mark an X on line beside those which will light.



3. Using the materials below draw a diagram that shows how you would connect these materials to make a complete circuit.



4.  What happens if just bulb one is removed from its socket? _____
What happens if just bulb two is removed from its socket? _____
What happens if just bulb three is removed from its socket? _____

5. Name two materials that conduct electricity.

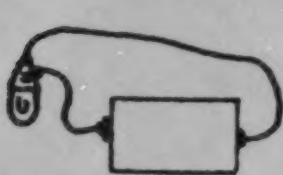
(1) _____ (2) _____

6. Name two materials that insulate electricity.

(1) _____ (2) _____

ELECTRICITY ASSESSMENTSECTION A

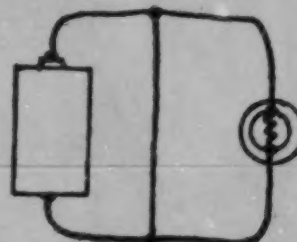
1. In the examples below place an X in the box marked "yes" if the bulb will light and an X in the box marked "no" if the bulb will not light.



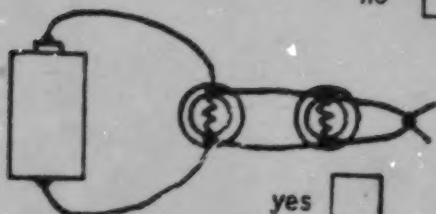
yes ☐
no ☐



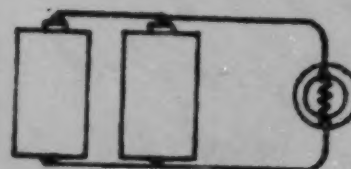
yes ☐
no ☐



yes ☐
no ☐



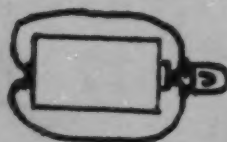
yes ☐
no ☐



yes ☐ no ☐



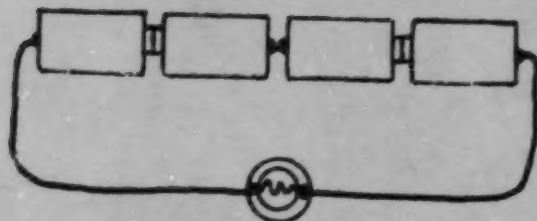
yes ☐
no ☐



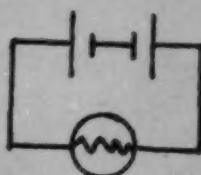
yes ☐
no ☐



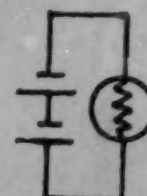
yes ☐ no ☐



yes ☐ no ☐



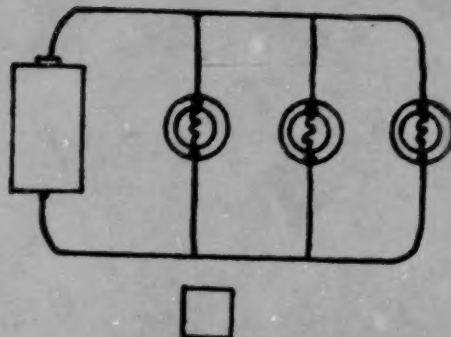
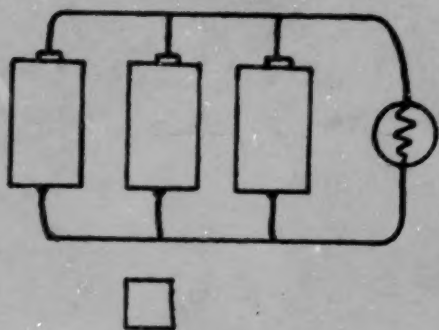
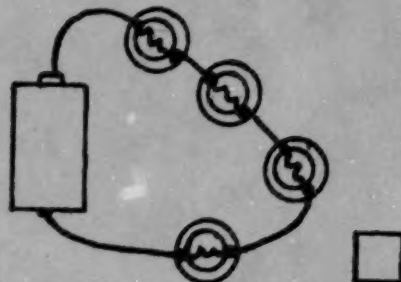
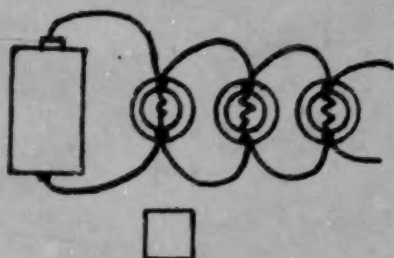
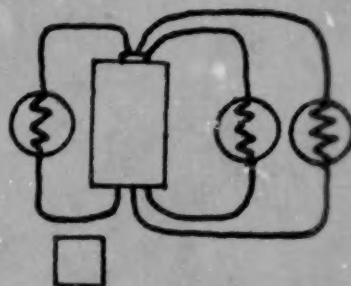
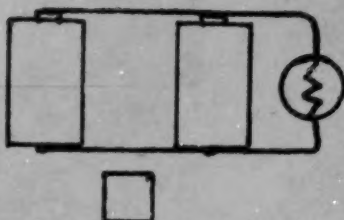
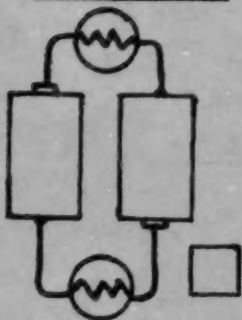
yes ☐
no ☐



yes ☐
no ☐

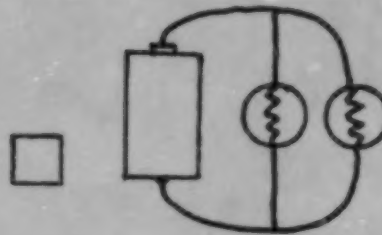
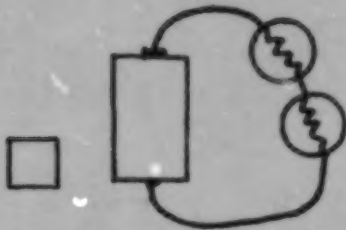
ELECTRICITY ASSESSMENT Section A

2. Write the letter "P" in the box by each parallel circuit and an "S" by each series circuit.

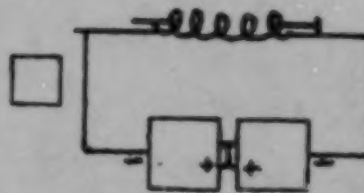
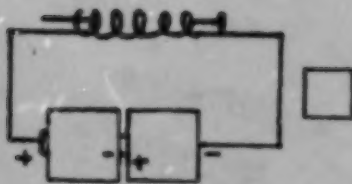


ELECTRICITY ASSESSMENT Section A

3. Put an X in the box beside the circuit that will have the brighter lights.

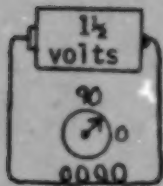


4. Put an X in the box beside the circuit that will pick up paper clips.

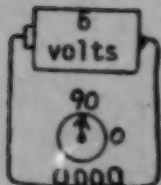


SECTION B

1. A galvanometer is a meter for measuring current. A strong current measures 90°, no current measures 0°. After looking at the three pictures below, explain why you think each meter has the reading it does.



A _____



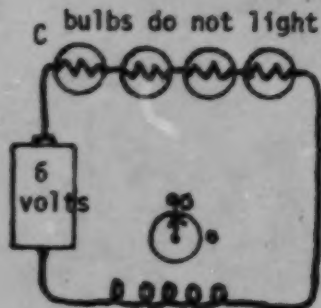
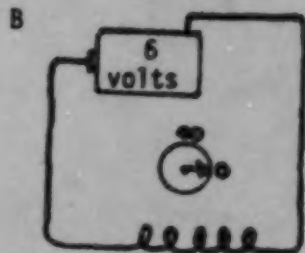
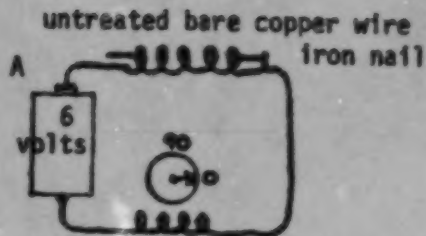
B _____



C _____

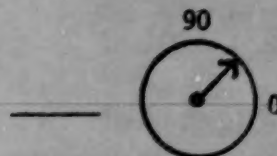
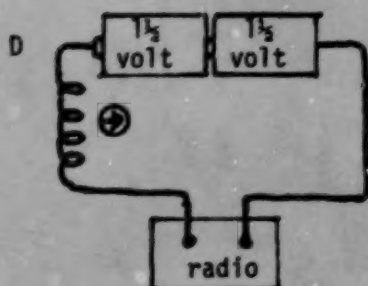
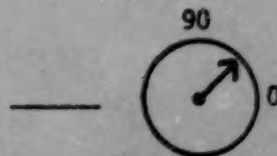
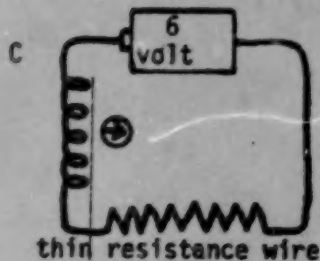
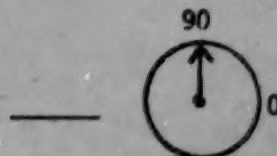
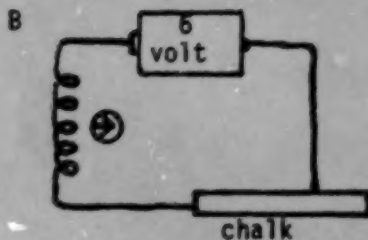
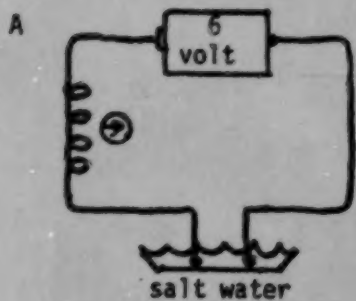
ELECTRICITY ASSESSMENT Section B

2. After looking at the three pictures below, explain why each meter has the reading it does.



ELECTRICITY ASSESSMENT Section B

3. In the pictures at the left are some circuits that have a meter attached to them.  is the symbol for that meter. At the right are some readings. Match the circuits with the meter reading that you think each circuit would have.

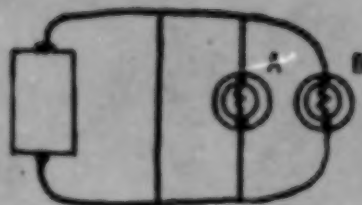


ELECTRICITY ASSESSMENT

SECTION C

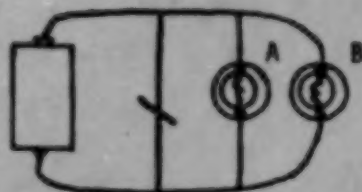
1. In the diagram below what will happen to the bulbs? Put an X in front of the correct answer.

- ☐ A and B will light.
- ☐ A and B will not light.
- ☐ A only will light.
- ☐ B only will light.



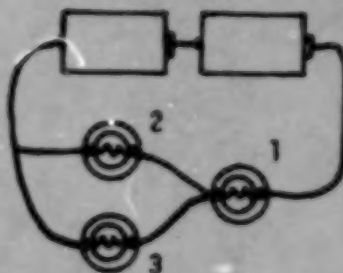
2. If a break were made in the circuit as shown below (X), what happens to the other bulbs?

- ☐ A and B will light.
- ☐ A and B will not light.
- ☐ A only will light.
- ☐ B only will light.



3. What happens in the circuit below when the number one bulb is removed from its socket?

- ☐ Nothing
- ☐ Number two bulb gets dimmer.
- ☐ Bulb number two gets brighter.
- ☐ Other bulbs go out.
- ☐ Bulb number three gets brighter.
- ☐ Bulb number three gets dimmer.

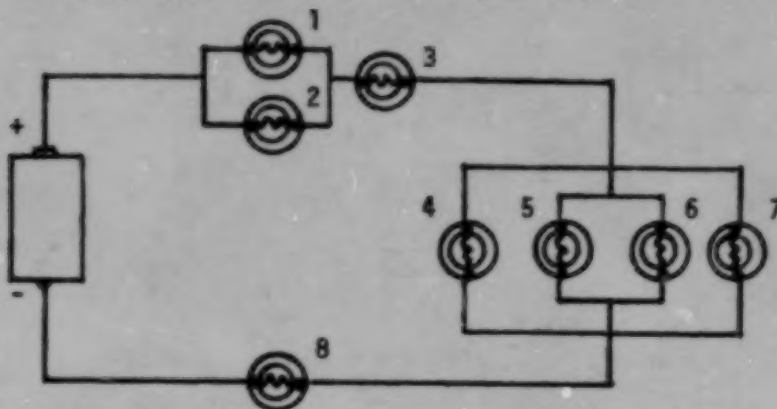


4. What happens in the same circuit above when the number two bulb is removed from its socket?

- ☐ Nothing
- ☐ The other bulbs go out.
- ☐ Bulb number one gets brighter.
- ☐ Bulb number one gets dimmer.
- ☐ Bulb number three gets dimmer.
- ☐ Bulb number three goes out.

ELECTRICITY ASSESSMENT Section C

Answer the following questions about the diagram below:



5. If you remove number five and number six bulbs what will happen to the circuit? Put an X in front of the correct answer.
- ☐ Four and seven will also go out.
- ☐ One and two will also go out.
- ☐ Nothing.
- ☐ All the bulbs will go out.
6. If you remove number three, what will happen to the circuit? Put an X in front of the correct answer.
- ☐ All will go out except one and two.
- ☐ Just three will go out.
- ☐ Nothing.
- ☐ All the bulbs will go out.
7. What two bulbs, if removed, would keep all the other bulbs from lighting? Put an X in front of the correct answer.
- ☐ One and four.
- ☐ Three and eight.
- ☐ Five and six.
- ☐ Four and seven.

ELECTRICITY ASSESSMENT Section C

8. The flow of electrical current moves from (see picture on Page 7.)

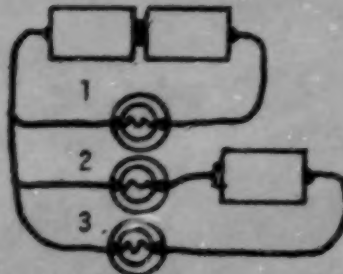
- ☐ the negative side of the battery towards bulb's eight.
- ☐ the positive side of the battery towards bulbs one and two.
- ☐ from both positive and negative sides of the battery.
- ☐ from north to south.

9. In the picture to the right what will happen to bulb number one? Put an X in front of the correct answer.

- ☐ It will light.
- ☐ It will not light.

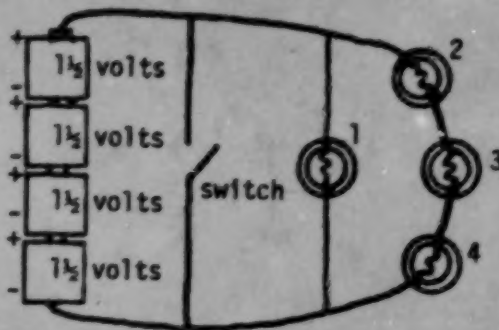
What will happen to bulbs two and three?

- ☐ They will light.
- ☐ They will not light.



SECTION D

Look at the circuit below carefully.



1. Put an X in front of the statements below that would be true about the circuit as it appears above with the switch open.

- ☐ Very hot wires
- ☐ Fast chemical reaction
- ☐ All bulbs will be lighted
- ☐ Number one bulb will be brighter than the rest
- ☐ Number three bulb will be brighter than the rest
- ☐ The flow of current moves from the negative end of the battery toward the positive end of battery
- ☐ 6 volt power source

ELECTRICITY ASSESSMENT Section D

2. Now put an X in front of the statements below that would be true if the switch were closed. (See picture on Page 8.)

_____ Very hot wires.

_____ Fast chemical reaction.

_____ All bulbs will be lighted.

_____ Number one bulb will be brighter than the rest.

_____ Number three bulb will be brighter than the rest.

_____ The flow of current moves from the negative end of the battery toward the positive end of battery.

_____ 6 volt power source.

ELECTRICITY - BEGINNING CIRCUITRY

Beginning circuitry is an introduction to the study of electricity and magnetism. In the course of this study, each child carries out experiments with his/her own simple equipment: flashlight batteries, small bulbs, various kinds of wire, magnets, a compass--and draws conclusions based on his/her observations of these experiments. The student workbook* is designed to be used in conjunction with Batteries and Bulbs, McGraw-Hill.

Activities:

Part I

Ways to Light a Bulb
What's Inside a Bulb
Battery Holders
Bulb Holders
Series and Parallel Circuits
Schematics
Mystery Boxes
Testing Pathways
Making a Bulb

Part II

Magnets
The Compass
Electromagnet
Buzzer
Motor
Testing Device

ELECTRICITY - INTERMEDIATE PROJECTS

There are many interesting and exciting projects for students to make in this packet, but best of all there are ideas for "original student inventions" as well. Before students feel confident enough to pursue these, they must get a "handle" on basic circuitry and have made some of the projects in this book.

Activities:

Making a Battery
Teaching Machine
Space Shot
Designing an Electric Meter That Measures
The Flow of Electricity
Electric Mouse
Electric Hammer
Telegraph Set
Electric Flag

*Workbook goes with Batteries and Bulbs II, ESS McGraw-Hill.

ELECTRICITY PROGRAM SUPPLIES

Quantity	Item	Unit Cost	Per Class (10)	Per Student
1	Batteries and Bulbs I* (07-017491-1) (Teacher's Guide and Workbook combined)	7.32	7.32	.73
5	Student Sheets* (07-017492-X)	2.12	10.60	1.06
1	Class Kit* (07-018416-X)	129.51	129.51	13.00
1	Batteries and Bulbs II*(07-017713-9)	8.52	8.52	.85
7	1½ volt D batteries (24 per box) (Radioshack)	31.92	223.44	23.00
3 sets	alkaline batteries (Radioshack)	1.39	4.17	.42
10	6-volt batteries (Radioshack)	1.59	15.90	1.60
4	Electricity Dictionaries (Radioshack)	1.99	7.96	.80
1 per	Student notebooks (North Kitsap School District--Poulsbo, WA)			

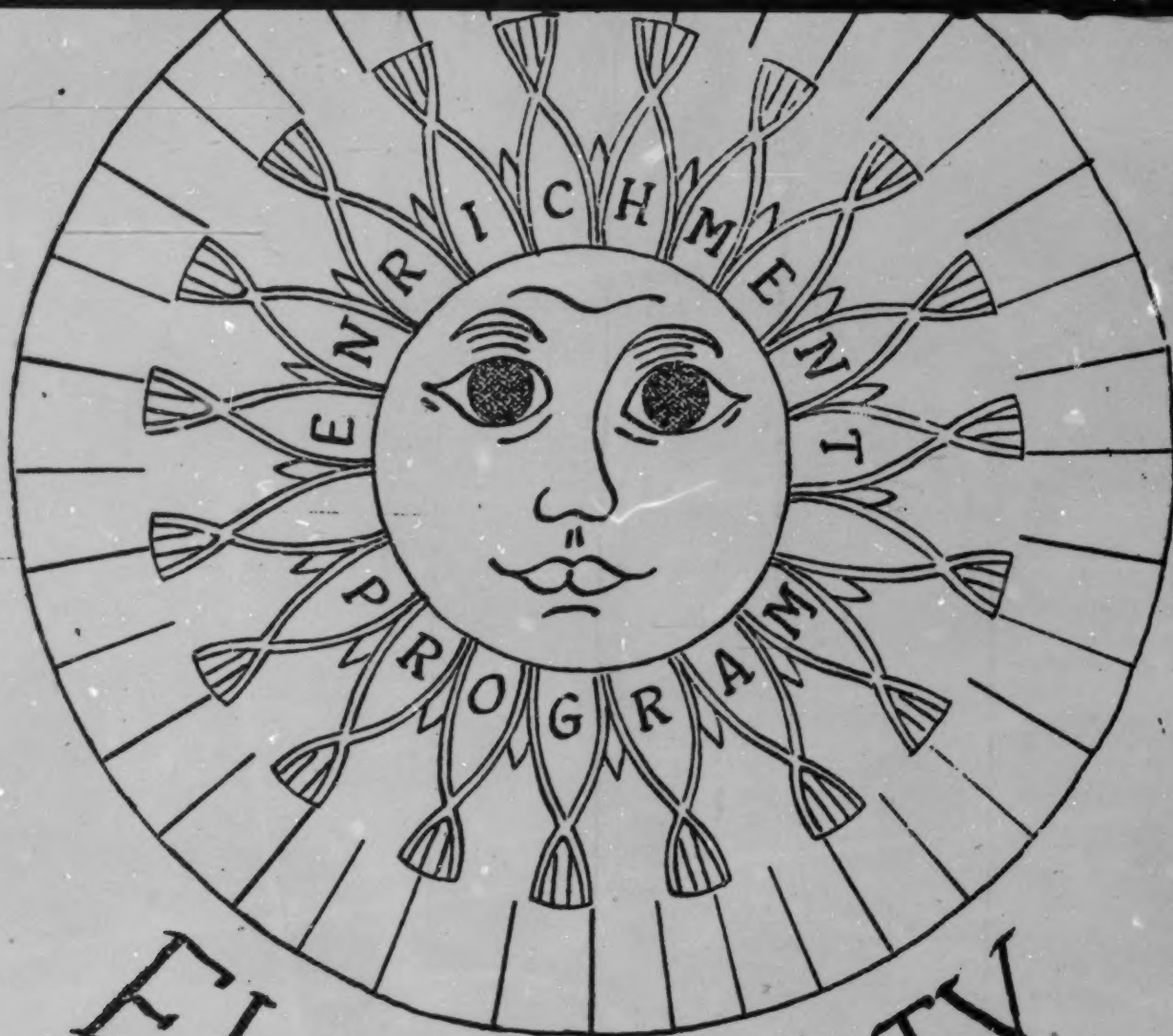
ESS-McGraw Hill

Cost per class
approx.

\$408.00

Cost per
student
approx.

\$42.00



ELECTRICITY

VOCABULARY LISTS

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North Kitsap School District #400
150 High School Road South
Poulsbo, WA 98370

VOCABULARY LIST #1

Name _____

Give the definition of the following words:

1. current _____

2. experiment _____

3. electricity _____

4. path _____

5. circuit _____

6. "in series" _____

7. parallel _____

8. filament _____

9. polarity _____

10. power source _____

11. connector _____

12. magnet _____

13. battery _____

14. Nichrome _____

15. Fahnestock clip _____

16. alligator clip _____

17. bulb _____

18. short-circuit _____

19. poles _____

20. flow _____

21. negative _____

22. positive _____

23. watt _____

24. carbon rod _____

25. dry cell _____

26. wet cell _____

VOCABULARY #2

Name _____

Give the definition of the following words:

1. resistor _____

2. conductor _____

3. insulator _____

4. schematic _____

5. electromagnet _____

6. coil _____

7. magnetic field _____

8. compass _____

9. transistor _____

10. magnetized _____

11. diameter _____

12. radius _____

13. enamel coating _____

14. switch _____

15. meter _____

16. volts _____

17. magnetism _____

18. testing device _____

19. galvanometer _____

20. prediction _____

21. hypothesis _____

22. conclusion _____

VOCABULARY LIST NO. 1 KEY

1. current - the flow of electrons through a conductor.
2. experiment - a test or trial to illustrate a known law or to establish a hypothesis.
3. electricity - the force exerted by electrons.
4. path - route taken by electrons.
5. circuit - the path taken by the current from an electrical source and back again.
6. "in series" - the connecting of components in a circuit end to end to provide a single path for the current.
7. parallel - the connecting of two or more parts of a circuit to the same pair of terminals so that current divides between the parts.
8. filament - a very thin metal wire inside a bulb that can be heated to a very high temperature without melting and will glow.
9. polarity - the particular state either positive or negative with reference to the two poles or to electrification.
10. power source - point of origin for supplying energy, e.g., a battery.
11. connector - a coupling device that provides for joining of electrical wire terminations.
12. magnet - a body that has the property of attracting or repelling magnetic materials, e.g., iron or steel.
13. battery - a group of electric cells that change chemical energy into electric energy.
14. nichrome - wire made of nickel and chromium that will give off a great deal of heat or light without melting.
15. Fahnestock clip - a connector for making a circuit.
16. alligator clip - a connector for making a circuit.
17. bulb - the glass envelope enclosing the light source of an electric lamp.
18. short circuit - an abnormal connection of relatively low resistance between two points of a circuit, resulting in a flow of excess current between these two points.
19. poles - the terminal of a battery; the end of a magnet.

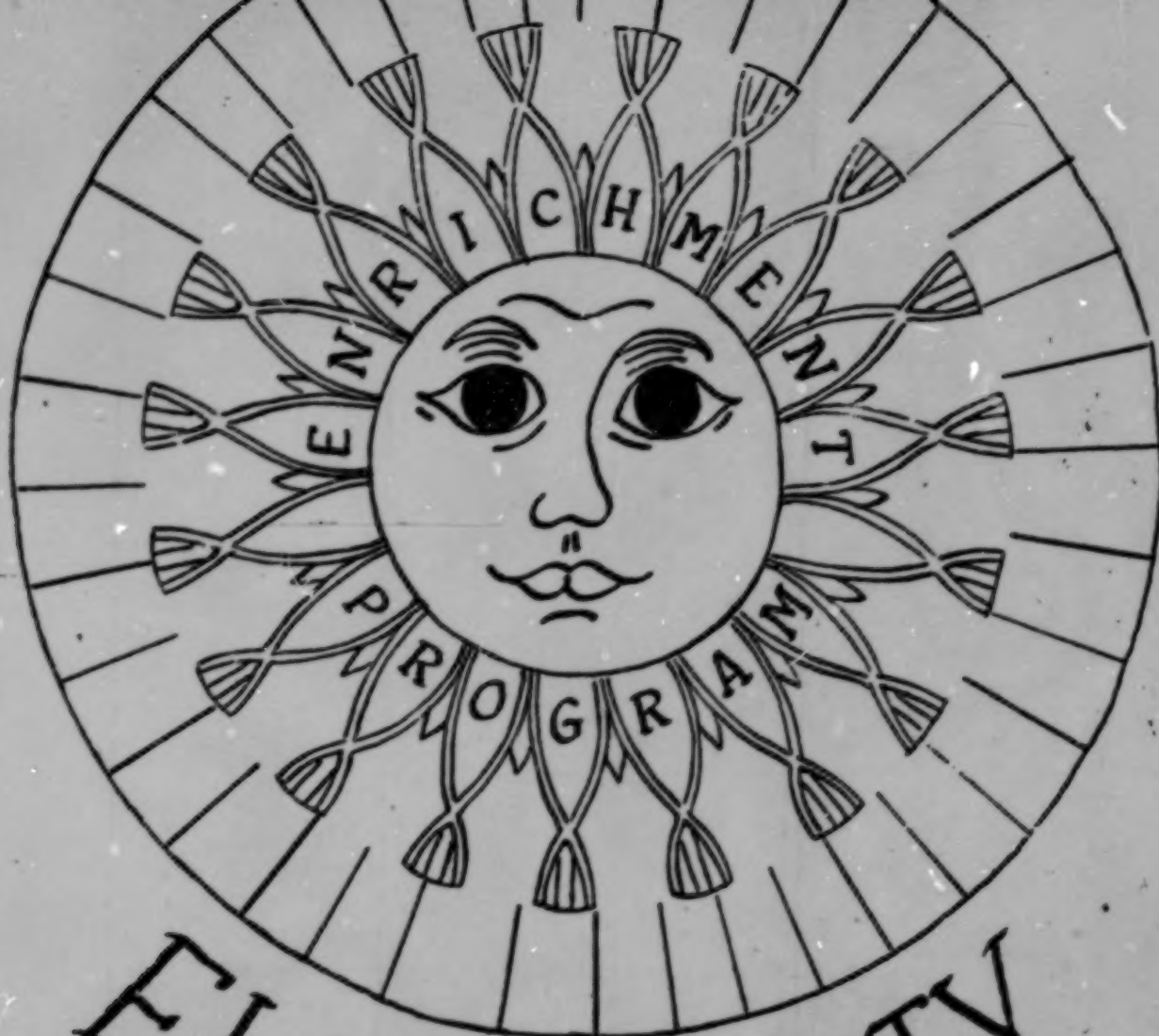
20. flow - the passage of electrons (a current) through a connector.
21. negative - a terminal having an excess of electrons.
22. positive - a terminal having a shortage of electrons; a point to which electrons are attracted.
23. watt - (1) unit for measuring the combined quantity and force of an electric current in one second. (2) power expended when one ampere of direct current flows through a resistance of one ohm.
24. carbon rod - the positive pole in the center of a battery.
25. dry cell - an electric cell made of zinc, carbon, and ammonium chloride.
26. wet cell - an electric cell made of distilled water, acid and copper and/or zinc.
27. electric cell - unit composed of two unlike materials and a chemical that will react with them.
28. ampere - a unit of electrical current or rate of flow of electrons. One volt across one ohm of resistance causes a current flow of one ampere.
29. ohm - unit of resistance.
30. volt - unit for measuring the force of an electric current.
31. resistance - the property of a substance which impedes current.

VOCABULARY LIST NO. 2 KEY

1. resistor - a device connected into an electrical circuit to introduce a specified resistance.
2. conductor - material through which electricity flows.
3. insulator - material through which electricity does not flow easily.
4. schematic - a diagram of the electrical scheme of a circuit with components represented by graphical symbols.
5. electromagnet - magnet produced by electricity flowing through a cell.
6. coil - a number of turns of wire wound around an iron core or onto a form made of insulating material or self supporting.
7. magnetic field - an area where magnetic forces can be detected around a type of magnet.
8. compass - a device for determining direction by means of a magnetic needle turning freely on a pivot and pointing to the magnetic north.
9. transistor - an active semiconductor device usually made of silicon or germanium having three or more electrodes.
10. magnetized - capable of becoming a magnet.
11. diameter - the length of a straight line through the center of a body.
12. radius - a line segment extending from the center to the surface.
13. enamel coating - wire coated with a layer of baked-enamel insulation.
14. switch - a mechanical or electrical device that completes or breaks the path of the current or sends it over a different path.
15. meter - (1) any measuring device; specifically, any electrical or electronic measuring instrument. (2) a unit of measure in the metric system.
16. volts - the unit of measure of the force of an electric current.
17. magnetism - an ability to attract or the science that deals with magnetic phenomena.
18. testing device - an object for determining the manner in which equipment is functioning.
19. galvanometer - meter that detects small currents of electricity.
20. prediction - the act of forecasting or foretelling on the basis of observation, experience or scientific reason.

Vocabulary List No. 2 Key
Page 2

21. hypothesis - a tentative assumption made in order to draw out and test its logical result.
22. conclusion - a final summing up; result, outcome; termination, end.



ELECTRICITY

BEGINNING CIRCUITRY
Workbook to go with
Batteries and Bulbs I
ESS McGraw Hill

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Developed by
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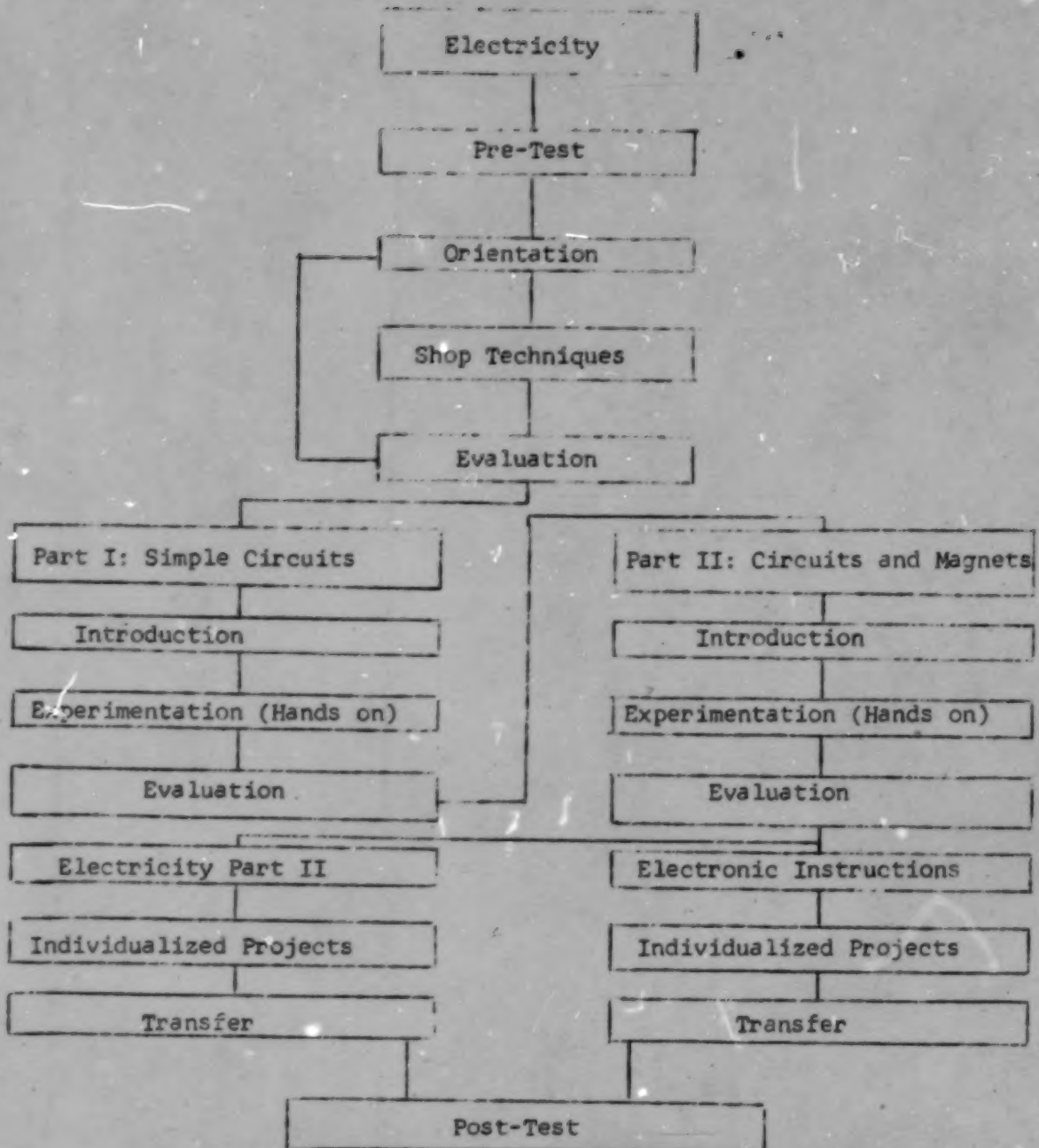


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- D. Buzzer
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PART I

A. WAYS TO LIGHT A BULB

Materials used:

Give at least five examples of ways a bulb will light (make drawings):

Give at least four examples of ways a bulb will not light (make drawings):

A WAYS TO LIGHT A BULB (continued)

What don't the above samples light?

What special places must be touched on the bulb for it to light?

What special places must be touched on the battery for it to light?

Make a "rule" about lighting a bulb.

B. WHAT'S INSIDE A BULB

Materials used:

Make a diagram of the bulb and label all the parts:

Below, tell the function of each part if you know them:

B. WHAT'S INSIDE A BULB (continued)

What are some of the differences between a bulb which lights and one which does not light?

Why are the sides and bottom special places for lighting a bulb?

Can you tell what is inside a bulb by what happens when water enters the glass?

C. BATTERY HOLDERS

Materials used:

Invent two or three different kinds of battery holders. Below make a diagram of each

How could you short circuit a battery?

Does the rubber band have an effect on the bulb lighting? Explain.

What things can't you use?

What happens if a single wire is connected between the Fahnestock clips while the holder is on a battery?

D. BULB HOLDERS

Materials used:

Construct a bulb holder of your own and make a diagram of it below.

How does the bulb holder work?

How could you find out the brightness of a bulb? Explain one or two different ways.

E. SERIES AND PARALLEL CIRCUITS

Materials used:

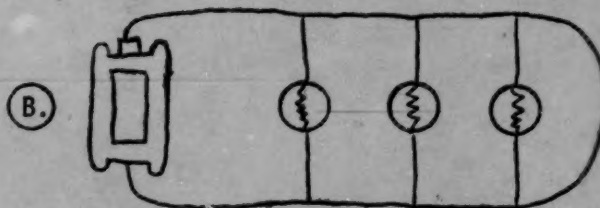
Construct two different circuits each with three bulbs so that the lights in one are brighter than the lights of the other. Make a diagram of this below.

Now construct the two set-ups below:

Series Circuit



Parallel Circuit



Which is brighter? _____ Why?

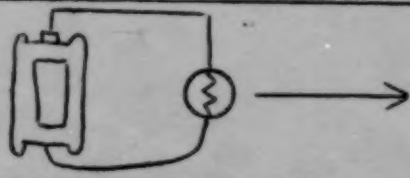
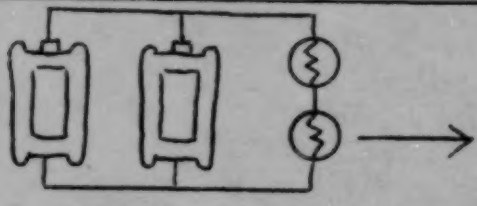
Set up some different parallel circuits and some different series circuits. Make a diagram of each below.

F. THE SECRET LANGUAGE

Below draw the symbols for the following:

battery	wire	bulbs	nichrome wire
Fahnestock clip	wires joined	wires crossed but not joined	

Make the circuits below using the "secret language."

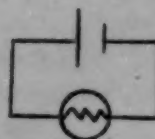
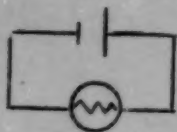
Now construct a new and different circuit using batteries, bulbs and wire. Then draw the circuit below in the "secret language."

These drawings using symbols are called "schematics".

Make schematics of two circuits below. Then give them to someone else to see if they can construct them using batteries, bulbs and wire.

F. THE SECRET LANGUAGE (continued)

Predict what will happen if you make up the two circuits below. Will the lighted bulbs be the same brightness? Why, or why not?



Below, draw any other symbols you know that could be used to represent other objects in a schematic drawing.

Why do we need a set of symbols to represent different electrical components?

G. MYSTERY BOX #1

Materials used:

Construct a mystery box of your own. Make a drawing of it below:

G. MYSTERY BOX #1 (continued)

Below, on the left, record your prediction of the wiring pattern for at least four different mystery boxes. Then, on the right, record the actual pattern. Use a testing device or you might try it without one first.

Prediction of Pattern	Actual Pattern
# _	
# _	
# _	
# _	

H. ANOTHER BULB

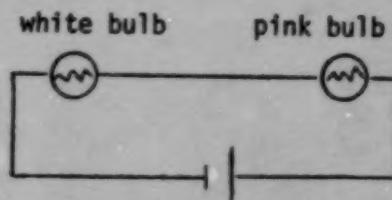
Materials used:

In what ways does the white bulb differ from the pink bulb?

Is the white bulb as bright as the pink bulb when put in a path with the same number of batteries?

Will the same number of white bulbs as pink bulbs light on one battery?

Construct the circuit below:



What happens?

See if you can make another construction so that the circuit will work. Make a diagram of the circuit below.

I. WHAT'S INSIDE A BATTERY

Materials used:

Make a diagram of a battery that has been opened and label the parts:

What parts of a battery are needed in order to light a bulb?

I. WHAT'S INSIDE A BATTERY (continued)

What materials that make up a battery can be put in a path to a pink bulb and still have the bulb light?

If you touch one end of the wire to the side of the battery after the covering has been removed, can you light a bulb with the other end of the wire?

What is the difference in the inside of a dead battery and the inside of a live one?

What is the difference in a dry cell battery and a wet cell?

J. TESTING PATHWAYS

Materials used:

Check out at least ten different objects and four different solutions to find out if they are conductors or nonconductors of electricity.

Conductors	Nonconductors

How is it that certain materials appear on both lists?

Will a second battery light the bulb? _____

Does it have to be a live battery to do this? _____

How does the pink bulb differ from the white bulb in a test of the same materials?

J. TESTING PATHWAYS (continued)

What do you get when you test pencil lead?

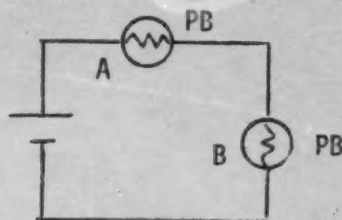
What do you get when you test different lengths of silver-colored (Nichrome) wire?

Are there any changes in the Fahnestock clips when you are testing liquid?

K. WIRES

Materials needed:

Make the circuit below:



Replace bulb A with a length of thin Nichrome wire that will make bulb B light with the same brightness as it did with bulb A in place. Does this give you a clue as to the way a bulb functions?

Below try different types and lengths of wire.

Type of Wire	Length of Wire That Makes the PB go Out	Length of Wire That Makes the WB go Out

Take a carton of salt water and put it in the path to a bulb and two batteries; then substitute a length of thick Nichrome wire long enough to dim the bulb the same amount as did the salt water. Approximately how long will this wire be?

Replace some of the bulbs in a circuit with thin Nichrome wire of lengths which will maintain the brightness of the rest of the bulbs in the circuit. What will this length be?

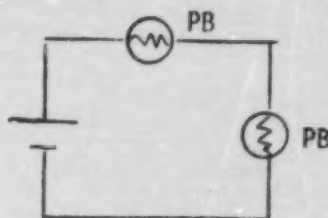
K. WIRES (continued)

If thick Nichrome wire in a circuit were replaced by the same length of thick plastic covered copper wire, would the bulb get brighter or dimmer?

If thin copper wire in a circuit were replaced by the same length of thin Nichrome wire, would the bulb get brighter or dimmer?

What length of thick Nichrome wire will dim a WB the same amount as 100 feet of thick plastic covered copper wire will?

In the circuit below, can you replace one of the pink bulbs with Nichrome wire in such a way that the brightness of the other bulb will be the same as before? About how long a piece of thin Nichrome wire will you need?



L. MAKING A BULB

Materials used:

Make a drawings of the bulb you have made. Label the different kinds of wire used.

What happens to the Nichrome wire when the model above has been completed?

Why does this happen?

L. MAKING A BULB (continued)

Will the Nichrome wire glow with one battery attached?

What happens when more than one battery is used?

Will the thick bare copper wire glow?

Why or why not?

Cross the support wires (bare copper wires). What happens to the bulb?

Will any other type of wire glow?

How much wire do you use?

How many batteries does it take to light this other wire?

M. MYSTERY BOX #2

Materials used:

With another student, construct a mystery box to challenge other members of the class. Draw a diagram of the circuitry below.

Design several testing devices that will give you an idea of what is inside another student's mystery box. Draw them below.

M. MYSTERY BOX #2 (continued)

With your partner, test at least three other mystery boxes. On the chart given, on the left make a diagram or schematic of your prediction of the circuitry inside and your reasons for making that choice. Then later, on the right make a diagram or schematic of the actual circuitry set up inside each box.

Prediction of Circuitry	Reasons for Your Choice	Actual Circuitry
# —		
# —		
# —		

PART II

A. MAGNETS

Make groups of materials that magnets will attract and those which they will not attract.

Attract	Will Not Attract

How can you compare the strength of one magnet to another?

A. MAGNETS (continued)

Will a battery with a wire attached to both ends affect a suspended magnet?

Where does the magnet face in relation to the wire? Does reversing the wire change anything?

What is "polarity"?

B. THE COMPASS

Make a list of materials that will move the compass needle and materials that will not move the needle.

Move	Will Not Move

Compare this list with the one made for magnets. What are the differences or similarities and why?

Use a compass in a circuit. What happens?

Now use different wires wrapped around the compass and record the readings on the compass. Be sure that the needle lies parallel to the coil's wire and points to zero on its scale before you take your reading.

Plastic-covered wire	
Enamel-coated wire	
Bare copper wire	
Nichrome wire	51

B. THE COMPASS (continued)

What happens if the loops of the coiled wire touch?

Why must the needle be parallel to the wires of the coil at the start?

How much will the needle move if a white bulb is put in the path from the battery to the coil?

--a pink bulb?

How many white bulbs can be put in the path with a fresh battery and still make the compass needle move?

Complete this chart.

Bulb	Number of Bulbs	Ten-turn Coil	Fifty-turn Coil
WB	1		
WB	2		
WB	3		
WB	4		
PB	1		
PB	2		
PB	3		
PB	4		

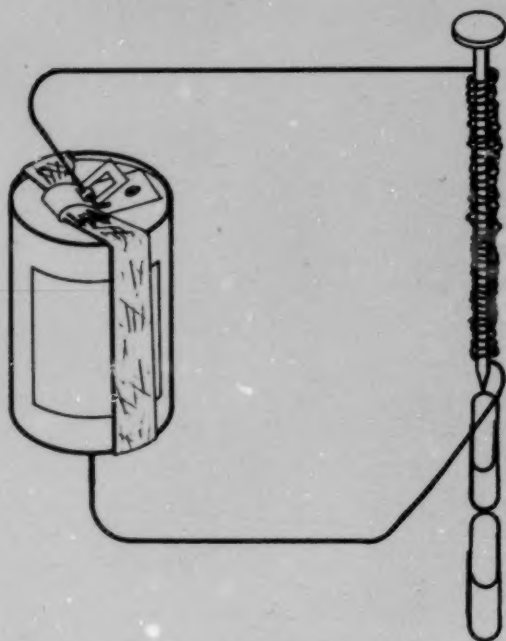
B. THE COMPASS (continued)

What does this chart tell you about the relationship of the brightness of a bulb to the distance the needle moves?

What does the chart tell you about the sensitivity of the galvanometer as the number of turns in the coil is increased?

Project Sheet 1

MAKING A STRONGER ELECTROMAGNET



How can you make your electromagnet lift more objects or heavier objects?

The following questions may help you test some of the parts of your electromagnet. As a measure of the electromagnet's strength, see how many paper clips it will pick up. The paper clips should be picked up end to end, so that the test can be done the same way each time. Before trying the questions, make a prediction about what you think will happen in each case.

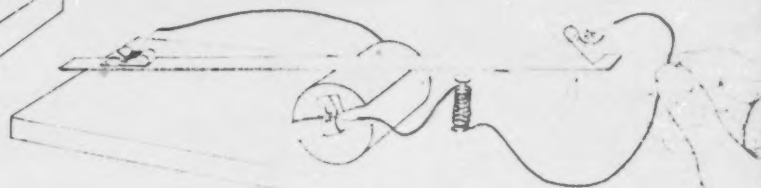
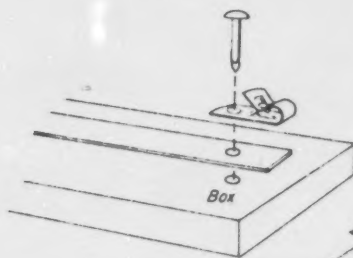
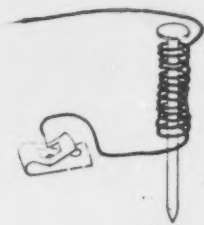
1. What happens when more than one battery is used in the path to the electromagnet?
2. Does the type of wire used make a difference? Does the length of wire make a difference?
3. Which type of material is best to wrap your coil around if you want to make a strong electromagnet?
4. What differences do you find between a coil wrapped on a thick piece of material and one wrapped on a thin piece?
5. Where is the best place on the magnet to pick up the paper clips?

Project Sheet 2

MAKING A BUZZER

Wind about one hundred turns of insulated wire close to the head of a nail. Leave eight inches of loose wire on both ends of the coil. Be sure to remove the insulation where connections are to be made. Put a Fahnestock clip on one of these ends.

Connect one end of a battery to one side of the coil and the other end to the Fahnestock clip which is at the end of the metal strip. Use a battery holder. The battery can be placed under the metal strip so that the metal strip is about a quarter inch above the head of the nail. Hold the wire with the Fahnestock clip attached about two inches from the clip. Touch the Fahnestock clip to the top of the metal strip at its loose end.



Connect the metal strip to the top of your shoe box by putting a paper fastener through a Fahnestock clip, through the metal strip, and then through the box. Push the nail part way into the box, under the strip.

Now that you have made the buzzer, here are some questions for you to think about:

1. How does the buzzer work?
2. Where is the path to the battery?
3. How can you make the sound higher? How can you make the sound lower?
4. What happens when more batteries are added?
5. Do you notice any difference in the buzzer if you add more turns of wire to the coil? ... if you take away turns?
6. If you use different wire or a different-sized nail, do you notice any change in the way the buzzer works?
7. Can you keep the buzzer going by itself?
8. Does raising or lowering the height of the nail make any change in the working of the buzzer?
9. If you touch the metal strip anywhere with the Fahnestock clip, does the buzzer still work? Does it work well?
10. Does the buzzer work as well if the strip is not directly over the nail?
11. How long will the buzzer work on one battery? How long will it work on two batteries placed end to end?
12. What happens if the nail is moved toward the tip of the attachment end of the strip? Do you have to move the battery?

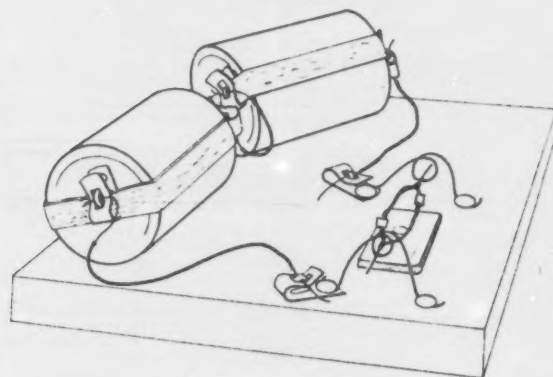
Project Sheet 3

MAKING AND TESTING A MOTOR

A stand for your motor can be made from two four-inch pieces of bare wire, four paper fasteners, and two Fahnestock clips. Make a loop in the middle of each wire by wrapping it once around a nail. Use paper fasteners to attach these wires—about two inches from each other—to the top of your shoe box. At one end of each wire put a paper fastener through a Fahnestock clip before attaching it to the box.

The moving coil can be made from a piece of enamel-coated wire about ten inches long. This piece is wrapped three times around the width of a ruler. Leave enough extra wire on both sides to be bent out straight away from the coil. Tape the coil in two places to keep the loops together. Clip the straight wires off so that the whole coil is about three inches long. Use sandpaper to take the enamel coating off the last $\frac{3}{4}$ inch of each straight wire.

Place one magnet on the box under the coil. Connect two batteries between the Fahnestock clips. To start the motor, you may have to give the coil a slight turn by twisting the end between your thumb and forefinger.



Now that you have made the motor, here are some questions for you to think about:

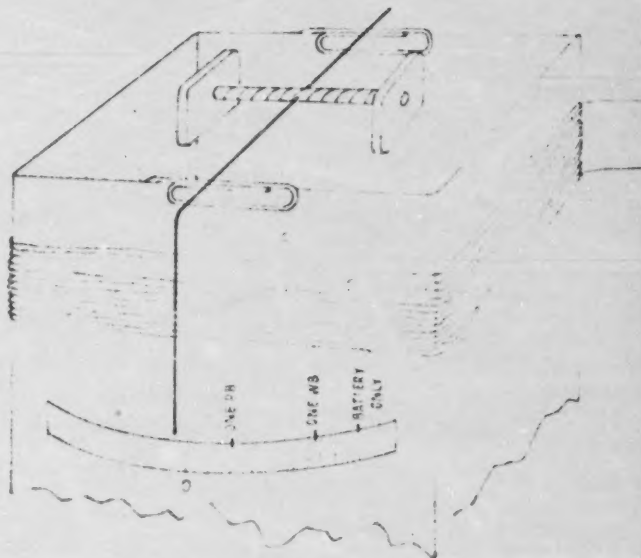
1. What will make your motor go faster? Will it work on only one D battery?
2. Why do you need a magnet? Can you use two magnets? Where can you place these magnets?
3. How does the end of the coil work as a switch?
4. Where is the path to the battery?
5. Can you make the motor turn the other way? What happens if the coil is put in the other way around?
6. Can you get the motor to start by itself?
7. Could the magnet be replaced by an electromagnet?

Project Sheet 4

ANOTHER TESTING DEVICE

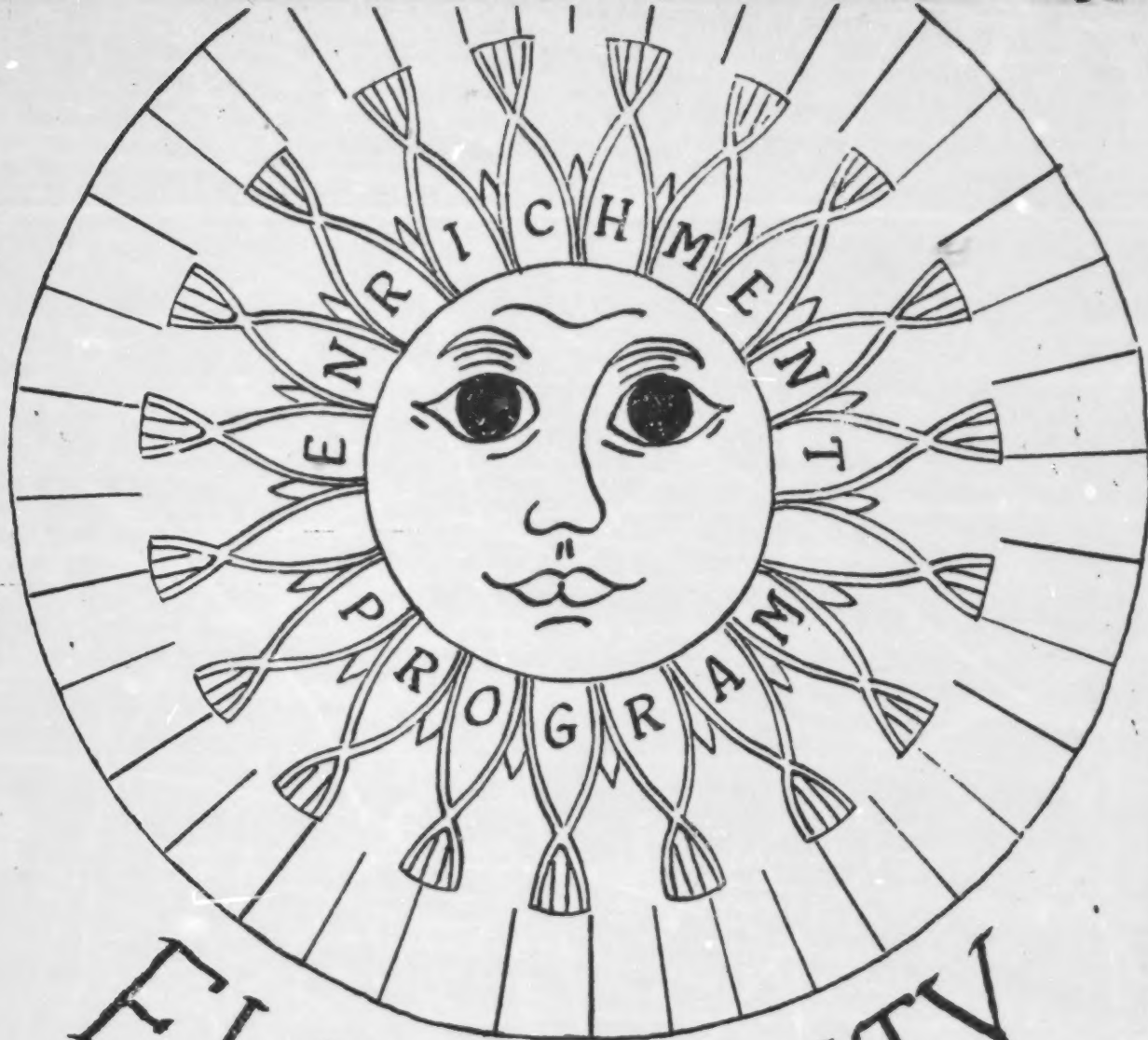
Cut the top off an empty half-pint milk carton, and wrap one hundred turns of enamel-coated wire around the middle of the container. Slide this coiled wire up to within half an inch of the top of the carton. Take off the enamel coating on the last $\frac{3}{4}$ inch of each wire. Place two paper clips on opposite top edges of the carton. Push a five-inch piece of thick (bare) copper wire through the sides of a piece of drinking straw $1\frac{1}{2}$ inches long. This wire should go through the top part of the straw in order to help maintain balance. Put a magnet at each end of the straw. The magnet will hold to the straw better if the holes of each magnet are first filled with clay. The attracting surfaces of the magnet should be facing away from each other.

It is difficult to level the straw, but it is possible to do this by taping the heavy copper wire to the straw in order to keep it from slipping in the joint and by adding small pieces of clay to the magnet on the lighter side. It might also be necessary to bend the copper wire slightly, to achieve a better balance and to have the pointing part of the wire hanging straight down.



Here are some questions about this new testing device you may want to answer:

1. What happens if you connect a battery to the two wires?
2. Why does the straw swing if the coil is part of the path to a battery?
3. What kind of scale can you make to show how much the pointer would swing if a PB, say, is put in the path between the coil and the battery?
4. Can you make the pointer swing the other way?
5. In what ways is this device better than the galvanometer you made?
6. Try this device in some of the circuits you used to study the galvanometer, for comparison with that instrument.



ELECTRICITY

INTERMEDIATE PROJECTS

Workbook to go with
Batteries and Bulbs II
ESS McGraw Hill

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Developed by
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Under ESEA Title III
North Kitsap School District #400
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BATTERIES AND BULBS II

There are many neat and exciting projects that kids can find to create in this book. But best of all there are ideas for "original student inventions" as well. But before kids feel confident enough to pursue these they must get a "handle" on basic circuitry and have made a few of the projects in this book and understand how they work.

The following projects have been made by many students. They always seem to be successful and are fairly easy to construct.

1. Construct three different kinds of bulb holders (p. 23-25).
2. Construct two different kinds of switches (p. 26-28).
3. Construct one type of buzzer (p. 34-37).
4. Construct a circuit board and be able to explain how it works and any patterns or strategies created involving circuit pathways (43-47).
5. Construct two different kinds of street lights (p. 58-59).
6. Construct a telegraph code sender (p. 64-65).
7. Construct a nerve tester (p. 74-75).
8. Construct an electric maze (p. 77-79).
9. Construct a coin-pitching game (p. 80-81).
10. Construct a motor (p. 85-90).

Student could start by making five or six of these projects, some easy, some more difficult (they are listed with the easiest first). Students should make a schematic drawing and a brief explanation about every construction he or she completes on 5" x 7" file cards to be displayed with the completed project. In this way kids can be trying out each other's creations and testing to see the different ways people have constructed the same things.

Then students should try to make their own "invention." Have them look at and discuss the different ways people have constructed the same things.

Then students can work individually or in pairs to create their own inventions. Research should be done in the library along with detailed planning of the construction including schematic drawings and written explanation of the way the invention works. Have students take a look at the list on page 128 for ideas for other inventions.

As students complete inventions they need to share these with other students in the school. There could be a bulletin board display with "Inventor of the Week" including a picture of the inventor(s) themselves, a write-up about their inventions and how they became interested in this particular type of gadget.

TABLE OF CONTENTS

Making a Battery

Teaching Machine

Space Shot

Designing an Electric Meter That Measures
the Flow of Electricity

Moving Mouse

Electric Hammer

Telegraph Set

Electric Flag

Note: Additional electrical materials and workbooks can be ordered
from Science Curriculum Improvement Study, Rand McNally and Co.,
Chicago; New York; San Francisco.

MAKING A BATTERY

This activity is to help the student learn the chemistry, composition, and conditions for operation of an electric battery.

Materials: 2 4" x 12" strips of household aluminum foil
2 6-oz. jelly glasses or tumblers
2 4" squares (double thickness) of paper towel
1 2' long piece of lamp cord
1 wire stripper
1 flashlight battery
1 conductivity tester
1 bottle of household bleach
2 tsp. baking soda
2 paper clips
2 balls copper wire

Procedure:

Cut two 4" x 12" strips of household aluminum foil, fold one end of each and crumple the rest loosely. Stuff each one into the bottom of the jelly jar or tumbler.

Cut two double-thick 4-inch squares of paper towel and stuff one of these down on top of the aluminum foil in each cell.

Cut the piece of lamp cord 2-feet long and strip two inches of insulation from one end of each piece and 12 inches from the other. Crumple them into a loose ball about 1-inch in diameter. Place one ball on top of the paper towel in each cell. The 2-inch end of one copper electrode is to be joined with the other cell by twisting them together.

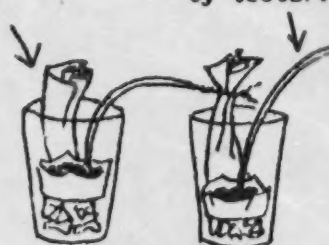
Remove the flashlight battery conductivity tester. Join the wire coming from the base of the bulb to the free aluminum electrode, slip the end of the free wire of the battery under the paper clip that holds the threaded part of the bulb.

Fill the cells with liquid household bleach until the ball of copper wire is nearly covered. Wait a few moments for the filament to glow faintly. Add a level teaspoonful of baking soda right on top of the ball of copper in each cell. At first, the bulb should flash momentarily, then settle down. In 15 minutes the bulb will become dimmer. To revive this, you can jiggle the copper electrodes so as to agitate the electrolyte and bring fresh electrolyte in contact with the copper. To improve the results you can add two tablespoons of bleach and one-half teaspoon of baking soda. The cells will stop when the aluminum is eaten through and breaks near the surface of the electrolyte.



Connect wire here from tip of bulb in conductivity tester

Slip ends of this wire under paper clip that holds threaded part of bulb in conductivity tester.

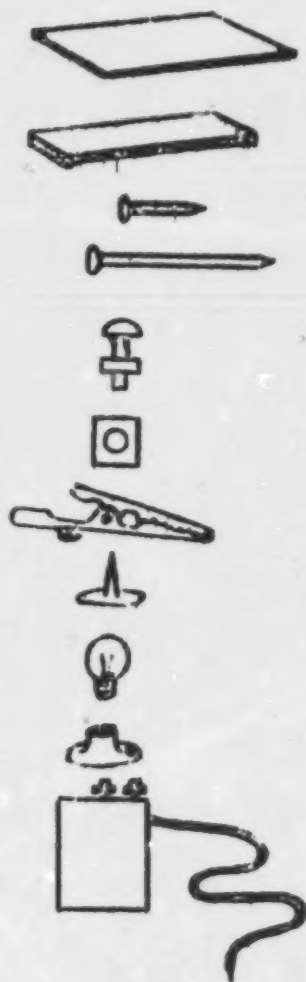


TEACHING MACHINE

This activity helps students learn how the use of electronic machines can make them learn more rapidly.

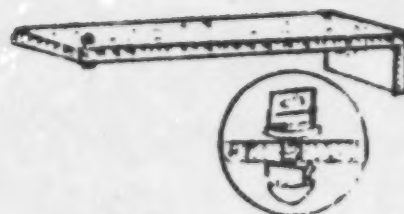
Materials:

- 1 12" x 18" $\frac{1}{4}$ " thick piece of plywood
- 1 6" x 18" $\frac{3}{4}$ " thick piece of plywood
- 5 $1\frac{1}{2}$ " nails
- 2 box 8 nails
- 24 $\frac{1}{8}$ " x 1" roundhead bolts, nuts and washers
- 24 $\frac{1}{8}$ " x 1" nuts
- 24 small alligator clips
- 2 small carpet tacks
- 1 $1\frac{1}{2}$ volt bulb and socket
- 1 $1\frac{1}{2}$ volt dry cell and 25-inches of bell wire

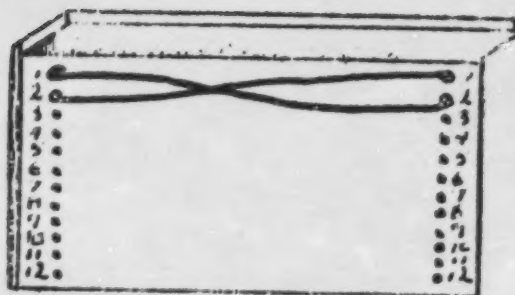


Procedure:

Use the 5 $1\frac{1}{2}$ nails and fasten the two boards together. Use a pencil to draw two vertical lines on the large board. Then mark off 12 short, horizontal lines $\frac{3}{4}$ " apart on each vertical line. Use a $\frac{1}{8}$ " bit and drill 24 holes where the vertical and horizontal lines cross. Then screw the 24 additional nuts tight against the heads of the 24 bolts. Bring the 24 bolts up from the bottom through the top board and place a washer over each bolt. Tighten them in place with a nut. Spaces alongside the bolts on the left side are used for questions, those on the right side are used for answers.



Cut 12 20-inch lengths of bell wire. Strip the insulation from the ends of each. Then fasten the end of each strip of bell wire to an alligator clip. Turn the board and number the holes on each vertical line from 1 to 12. Crisscross pairs of bolts by clamping the clips onto the bolt heads, always going from a "question" bolt to an "answer" bolt. Turn the board over, right side up. Using two carpet tacks, fasten the socket near the upper right hand corner.

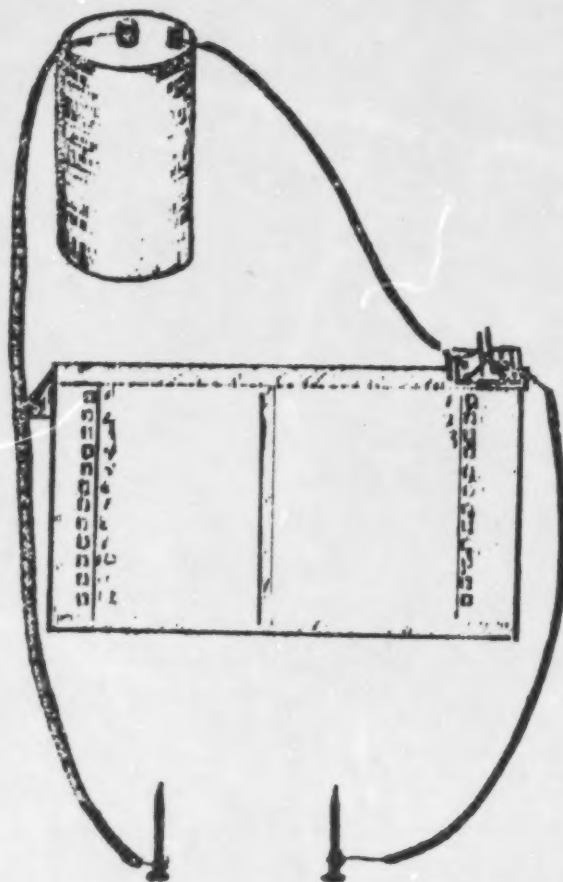


Use a short piece of bell wire and connect one terminal of the socket to the dry cell. Cut two pieces of bell wire about 24" in length. Fasten one end of each wire to one of the box-8 nails. Then connect the free end of one of the pieces of bell wire to the remaining terminal on the socket. Then do the same with the free end of the second piece of bell wire to the remaining terminal on the dry cell. The teaching machine is complete.

For your question sheet, you lay a piece of 8½" x 11" lined writing paper opposite the "question" bolts. Write the numbers 1 to 12 on the paper opposite the corresponding bolts, then do the same for the "answer" bolts.

Opposite each number on the question sheet, write a question from a book. Prepare your answer sheet. Each answer has to be written opposite the number corresponding to the "answer" bolt that is connected to the right "question" bolt. Then fasten your question and answer sheets in place on the teaching machine with a small piece of Scotch tape.

To play the game, a friend places one box-8 nail against a question bolt. He places the other against what he thinks is the correct "answer" bolt. If he is right, the light should flash on.

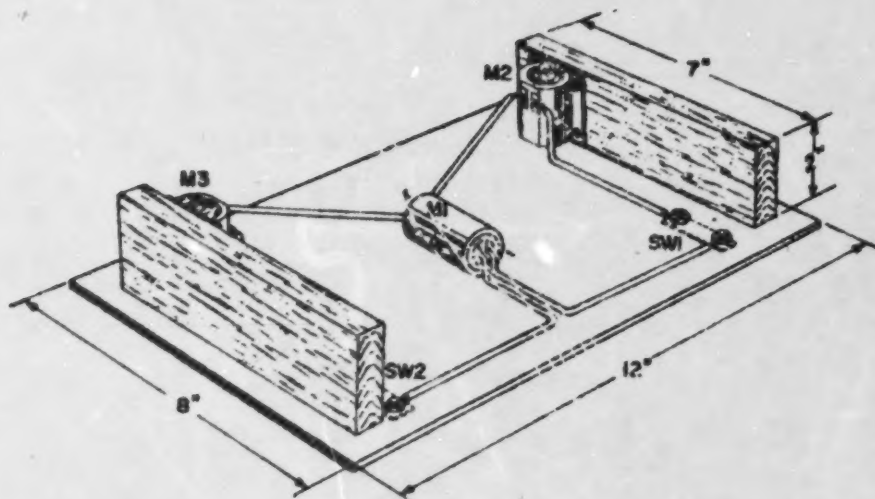


SPACE SHOT

This activity features two miniature "satellites" whirling in orbit.

Materials:

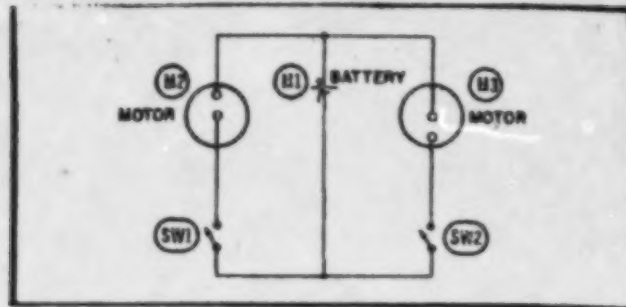
Number on Diagram	Quantity	Description
SW1, SW2	2	Switches
M1	1	Size D flashlight cell
M2, M3	2	1.5-3-volt miniature DC motors
	2	Ping-pong balls
	2	4½" x 3/8" dowels
	1	8" x 12" piece of hard-board
	2	7/8" x 2" x 7" wood strips
	2	5½" lengths of stiff wire (or use a coat hanger)
	4	Wood screws
	4	6-32 machine screws with nuts
		Hookup wire



Schematic #1

Procedure:

The schematic #2 of the "Space Shot" is as shown below:



The small DC motors rotate the posts whenever the buttons are depressed. A single battery provides the power. The direction in which the motor rotates depends on how its terminals are wired to the battery. An effect is achieved when the balls spin in opposite directions. In the model, the dark ball spins in a clockwise direction and the white one spins counterclockwise.

Schematic #2 of the project shows the dimensions of the board. The two wood strips are the mounting legs and serve as supporters for the motors. The motors are to be mounted by drilling two 1/2" holes for the shafts, then attach each motor to the sides of the wood strips with two wood screws.

The two posts on the top are fitted to the motor shafts, then cut two 3/8" pieces of wood dowel four inches long. Drill a small hole about half an inch deep into the ends of each dowel as near the center as possible.

Drill similar holes in the other ends of the dowels. Press a U-shaped wire (made from a paper clip) into each hole.

Prepare each ball and its wire with a thumbtack, puncture two holes along the "equator" on opposite sides of a ping-pong ball. Then pass a 5 1/2-inch wire through the holes, and bend up the end about one-fourth inch. Curve the wire slightly, next to the hole that will face the post, to keep the ball from sliding in this direction. Form the free end of the wire into a small loop and insert into the eye in the wood dowel. Make certain the ball is free to rise and fall as it spins around the post. Bend the loop if any binding is noticed.

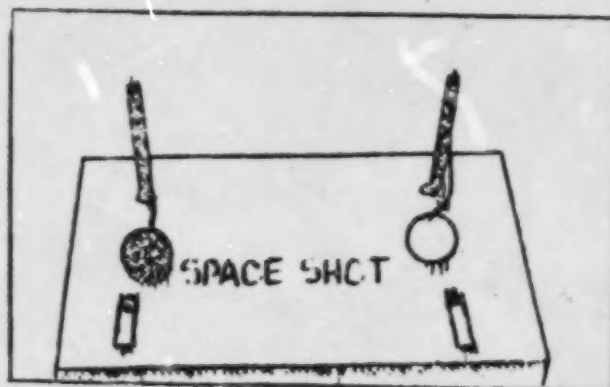
Repeat these steps for the ball.

Install a wooden post in the lower end of the dowel and press onto the motor shaft.

Cut two strips from a piece of copper (sold as copper flashing in hardware stores) and drill a hole at one end of each piece. Drill two holes on each side, near the front of the board. Insert 6-32 screws.

The battery is mounted underneath the board, near the center, as shown in Schematic #2. It can be cemented to the board, and the hookup wires soldered to the terminals, or you can use a battery holder and attach the hookup wire to its terminals. Connect the other ends of the battery wires to the motors and switches. Then add hookup wire from the switch terminals to the motors. The wires can be placed under the nuts on the switch terminals and the nuts tightened to hold in place. If the screws are plated, you can wrap the end of the wire around the screw and touch with solder.

The top of the "Space Shot" will look like this:



DESIGNING AN ELECTRIC METER THAT MEASURES THE FLOW OF ELECTRICITY

THE SOLENOID

The main part of this meter is a kind of electromagnet called a SOLENOID (SOLE-en-oid). It is made up of many turns of insulated wire coiled around a hollow tube.

The best wire to use for winding the solenoid is no. 22 cotton-covered copper wire. You will need only about 23 feet for a 200-turn solenoid. Ask a radio repairman or a hardware dealer to get you some.

Most commercial electromagnets are wound with copper wire, which is insulated with only a thin coat of enamel. You can use this too.

The turns of wire must be wrapped about a stiff tube of nonmagnetic material. It should be 6 inches long and about the diameter of a pencil. If you cannot find a tube like this, you can make it as follows:

Get a 4-inch by 6-inch rectangle of rather heavy paper, such as drawing paper. If you use ordinary writing paper, make the rectangle 4 inches by 8 inches. Place it flat and cover the top with glue, library paste, or a mixture of flour and water. Roll this around a long pencil into a tight, even, 4-inch tube. Wrap some string over the entire length to keep from unwinding.

Dry the glued tube in a warm place. Keep twisting the pencil inside the tube, so that the glue does not stick to the pencil. After a while remove the pencil and the string.

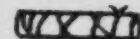
When ready to wind the wire, put the tube over a pencil again for support. Leave about 6 inches of wire free for making connections. Make your first loop around the tube about $\frac{1}{4}$ inch from the left end. Twist the wire tightly on itself several times. Don't let the wires unravel. Wind evenly. About every ten turns twist the pencil.

Wind until you come to about $\frac{1}{4}$ inch of the right end of the tube. Make your second layer of turns back over the first layer, going from right to left. Do not reverse your direction of winding each turn. All turns on a solenoid must be wound in the same direction. When you reach the starting point of the first layer, you must keep the coil from unraveling. Do this by carefully

- 1 PAPER, 4 X 6 INCHES,
SMEARED WITH PASTE OR
GLUE

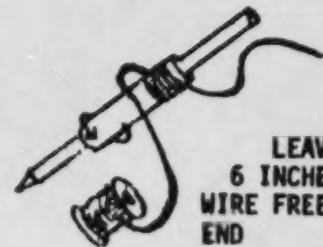


- 2 WRAP IT AROUND A PENCIL



- 3 TIE WITH THREAD
REMOVE PENCIL
LET DRY

- 4 PUT CYLINDER BACK ON
PENCIL



- 5 WRAP ABOUT 100 TURNS OF
WIRE AROUND CYLINDER
ALWAYS WIND WIRE IN THE
SAME DIRECTION

- 6 WRAP ABOUT 100 MORE TURNS
ON TOP OF THE FIRST 100



- 7
8 REMOVE PENCIL FROM SOLENOID

twisting the wire you are winding around the wire which started your coil and is sticking out. The two wires must not make bare-metal contact. Put some adhesive tape around one wire, before you twist the two wires.

The solenoid's plunger is a 4-inch steel "20-penny common nail" used by every carpenter. The "20-penny" refers to an old English weighing system and not to the price! Get one without deep ridges. The string is attached to the nail, as shown in the diagram, in order for the nail to hang straight up and down. It is also tied to the pointer in such a way that it can be moved to change the leverage. This is very important and delicate.

The backboard for the electric meter should be a 12-inch square piece of plywood or other wood. The wooden base should be wide enough to prevent toppling when the back is kept upright. Place the solenoid about $1\frac{1}{2}$ inches from the end. Keep it in place by wiring it to the backboard, or by staples. Wrap the ends of the solenoid wires around the connection nail. Remove the insulation first. Binding posts make better connections.

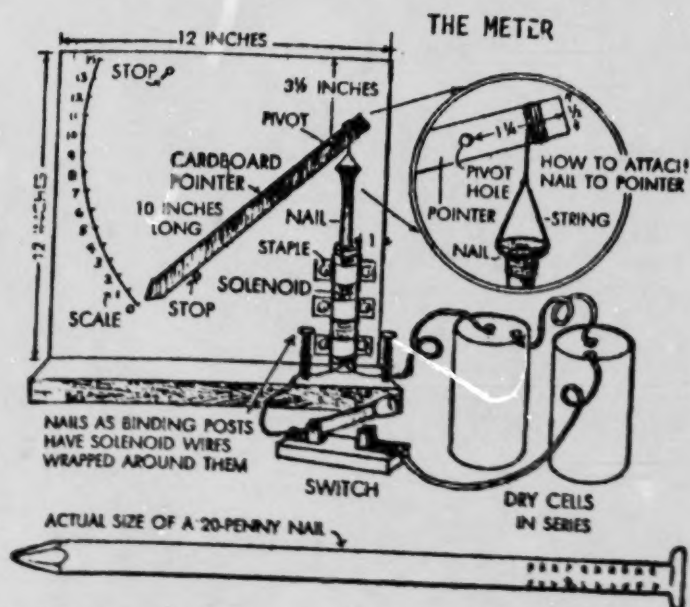
The pointer should be a very lightweight strip of wood. The weak force of the solenoid must be able to lift the pointer as the nail is drawn down. The length of the pointer should help to balance the nail when it is out of the solenoid. Moving the suspended nail away from the pivot brings the pointer up. The pivot should be loose. Use a washer at the pivot to keep the pointer from scraping the backboard.

Start with the dimensions shown in the diagram, then modify slightly so that the meter works most sensitively with your own materials. Connect your solenoid to a large $1\frac{1}{2}$ -volt dry cell. Then use several cells hooked up in series, as shown. Also use a flashlight cell. You should get different readings on your scale.

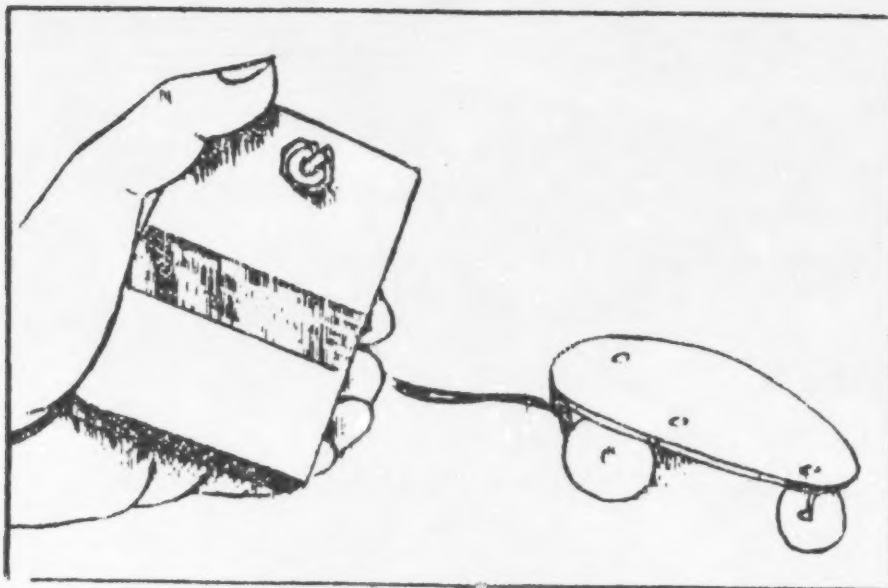
The scale does not tell you the exact number of volts or amperes. It is not designed for such accuracy. You can get excellent comparison readings for different sources of electricity. It will also show that there is a flow of electricity in a circuit.

You can greatly increase the sensitivity by varying many of the conditions, such as: 1) change the number of turns on the solenoid, also the size; having the nail at different depths in the tube when taking a reading; 2) use many different types of pointers, and methods of lifting the nail back to the zero position.

Do some research on solenoids in encyclopedias and science books. They are very useful in industry as well as in your own home. For example, in washing machines, there are many solenoids. Some open and close hot and cold water valves; others connect or release clutches and gears as the washer goes through its cycles.



THE MOVING MOUSE



Materials:

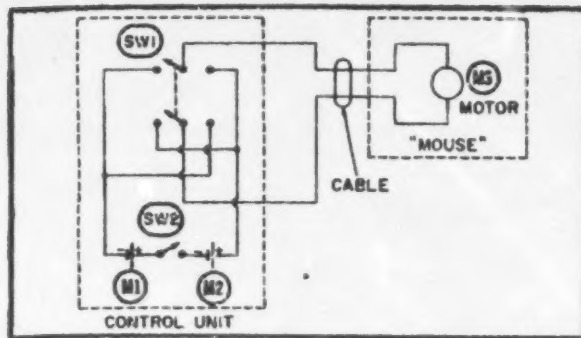
Number of Diagram	Quantity	Description
SW1	1	Double-pole, double throw switch
SW2	1	Alligator clip
M1, M2	2	Size D flashlight cells
M3	1	1.5- to 6-volt miniature DC motor
	1	4½" x 2½" piece hardboard
	1	5" piece hardboard (for "mouse")
	5'	No. 20 or No. 22 two-wire stranded cable
	3	Machine screws and nuts
		Stiff wire
		Hookup wire
		Copper flashing

Procedure:

The "mouse" is an interesting but difficult project. It can be stopped or backed up by remote control. The two basic sections are shown in the diagram. The hand is holding the control unit and the mouse is at the end of a control cable at the right. The switch on the control provides the forward-reverse function. When power is applied, the mouse proceeds across the floor. The reversing switch is flipped whenever the mouse reaches the end of the cable or its path is blocked. Students will need background in other simpler electrical projects before tackling this one.

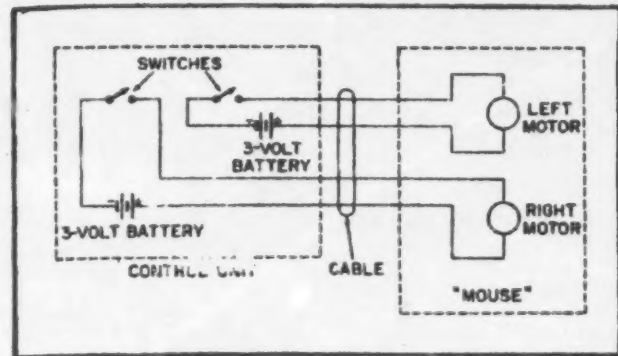
The "mouse" has two batteries in the control unit which send current, through the cable, to a small DC motor underneath the mouse. The switch reverses the polarity of the voltage applied to the DC motor and thus its direction of rotation.

Schematic #1



Schematic of the "Moving Mouse"

Schematic #2



Schematic of the "Moving Mouse With the Optional Two-Motor Drive For Steering

It is possible to make the mouse more maneuverable by using two motors, one for each wheel. In this way, you can steer the mouse to the right or left. This is shown in the Schematic #2 for those who wish to build a more advanced project. (A four-wire cable is required, plus two switches in the control unit. Both switches are pressed to provide equal power to both wheels and make the mouse go forward. For a left turn, the button controlling the left-wheel motor is released. This shuts off its power, and the other wheel then pivots the mouse around.)

This version does not allow reversing the direction of motion. Carrying the revision a step forward and using two double-pole, double-throw switches, each connected to a separate motor as shown in Schematic #1, permits forward or reverse movement and turns while traveling in each direction.

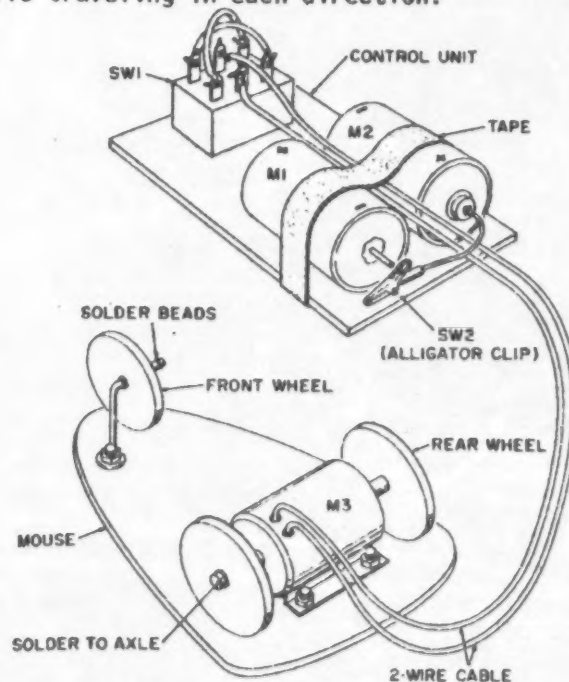


Diagram of the "Moving Mouse"

Cut two pieces of hardboard, one to 4" x 2½" for the control unit and the other about five inches long and in the shape of a mouse.

Attach the motor under the mouse with nuts and bolts. The wheel diameter should be slightly less than twice the space between the motor shaft and the underside of the board. Cut the three wheels from copper, drill a center hole in each, and solder two of them to the ends of the motor shaft. Bolt a piece of stiff wire to the board and bend it down for the axle. To keep the wheel in place, drop two beads of solder on the axle (on either side of the wheel).

Now, drill a hole and mount the reversing switch. Connect jumper wires across the switch terminals. Tape the batteries to the board and connect the leads from the battery to reversing switch terminals. Solder two short leads to the remaining battery terminals and solder an alligator clip to one lead. This clip becomes the on-off switch (SW2). To turn it off, just disconnect the clip.

The cable from the control unit to the mouse may be any length (around five feet). Flexible, stranded wires will least interfere with the movement of the mouse. If the mouse trips over the cable while backing up, give it a "tail" of stiff wire to hold the cable up and away from the rear wheels.

ELECTRIC HAMMER

The electric hammer is a fascinating project. In demonstrations it will break toothpicks and drive thumb tacks into soft wood.

Materials:

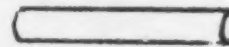
thumbtack



switch



3/8" (outside diameter)
4 3/4" copper tubing



board, 3/4" thick,
6" x 6"



bracket pieces



3/4" x 2" x 4 1/2" 3/4" x 2" x 2 3/4"

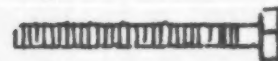
6 volt dry cell
battery



4 #6 box nails



1/4" x 4" machine
bolt

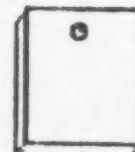


piece of cork cut
from bottle cork



Procedures:

Drill a hole in the 3/4" x 2" x 2 3/4" wood bracket piece, as shown. (Use a 5/32" wood bit if possible.)



Fasten the two wood bracket pieces together with two #6 box nails.

Wind about 100 turns of bell wire in the same direction around the copper tube. Leave at least a foot of wire at each end. Keep the wire coil tight by twisting the two end wires together.

Place bare end of tube in bracket hole. If hole is too small, cut larger with a piece of sandpaper or a small, sharp blade of a knife.

Place the 1/4" machine bolt (head-down) in the copper tube. Complete the bracket by nailing the assembled part to the baseboard (use two box-6 nails).

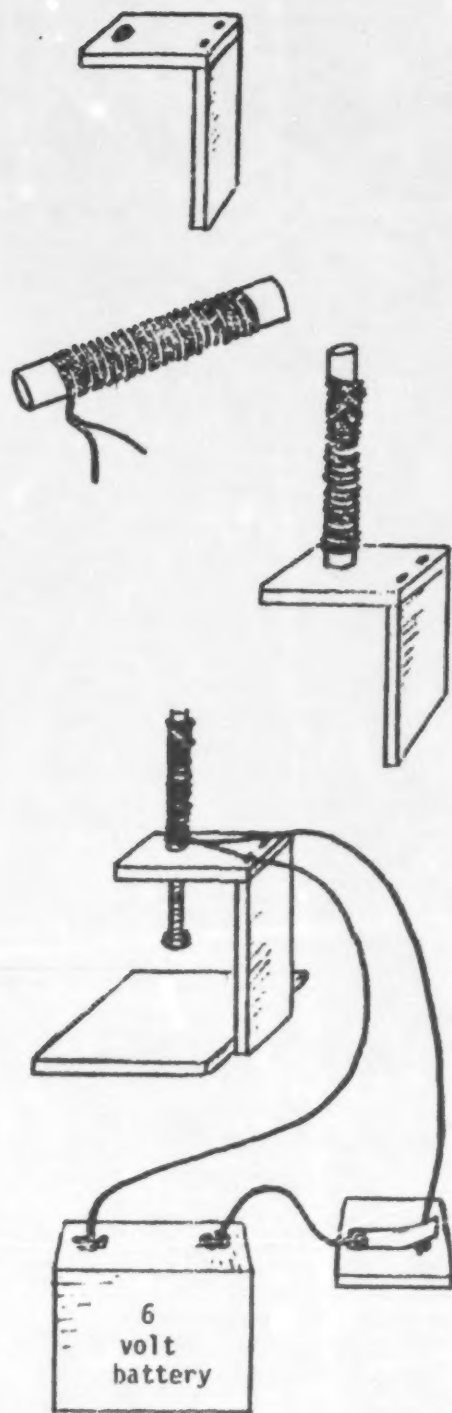
Scrape one-inch of insulation off ends of the two coil wires. Connect one to a battery terminal. Never connect the solenoid coil wires directly to a 110-120 volt circuit.

Connect the second coil wire to one of the switch terminals. Use a short piece of bell wire to connect the second switch terminal to the other battery terminal.

This is an electric hammer. Press the switch and a magnetic current is made. It causes the bolt to be sucked up into the coil. Release the switch and it causes the bolt to drop. Gravity is the force that causes the bolt to drop. When the switch is released the circuit is opened.

Ways to use the electric hammer:

1. Place a thumbtack in a piece of cork or soft wood. Press the switch. Place the tack under the bolt. Release switch. Press and release several times. This will force the thumbtack into the cork.
2. Break toothpicks propped against a pencil.



TELEGRAPH SET

Why does a telegraph click?
What does this click mean? (long-short-short-long)
How do you send messages?

Materials:



6 volt dry cell



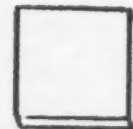
3 1/2" x #4
round-head screws



25' bell wire



5" x 2" piece of
galvanized iron or
heavy tin



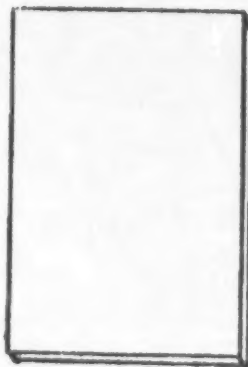
wood 3/4" thick
2" x 2"



2 box-8 nails



2 1 1/2" nails



plywood board 4" x 6"
(apple box crating will
also do.)



3/4" x 3"
galvanized iron
strip or heavy
tin

There are two main parts to a telegraph set:

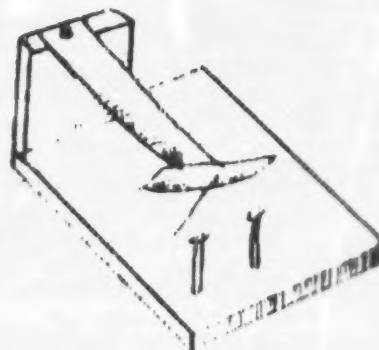
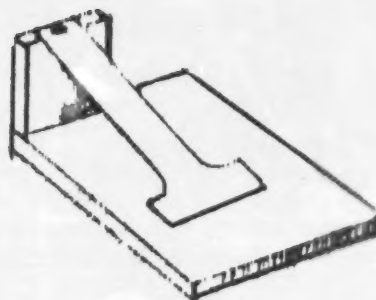
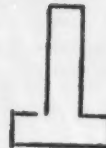
1. a sounder
2. a sender

The sounder will be made first. Use the two 1 1/2" nails to fasten the 3/4" x 2" x 2" block of wood to the 4" x 6" plywood boards.

Cut a T strip from the scrap piece of tin. Use a file to make edges smooth.

Fasten the T to the wood block with a 1/2" x 4" screw.

Pull T strip out of the way. Put in the two box-8 nails 1 3/4" apart so that the heads will be 2" above the plywood board.



Make the key by punching a hole in one end of the iron strip. Use one 1/2" x #4 round-head screw to fasten strip to plywood.

Bend iron strip so that free end is about 1/2" above plywood board.

Fasten other 1/2" x #4 round-head screw to the board underneath the free end of the key (iron strip). Scrape insulation from one end of bell wire. Connect it to screw under free end of key. Make a tight connection!

Now wind wire around nails (see picture)-- clockwise on first nail; counter clockwise on second nail.) Put 30 turns of wire on each nail. The windings on the first nail should end at the bottom and those on the second nail end at the top. Leave a foot of wire from the second nail and connect it to one of the 6 volt batteries. Then connect other terminal on the battery to the key. Be sure connections are tight.

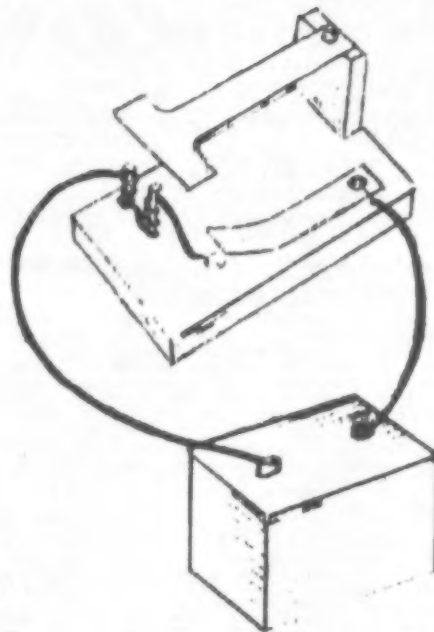
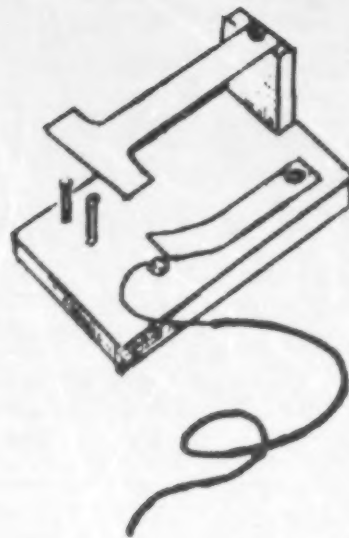
Make sure that the space left between the nail heads and the T-shaped strip is about the thickness of a table knife blade. Now press the key and then release it. There should be a click from the strip. Adjust the space between the T-strip and the nail heads until there is a good "click". This can be done by bending the metal slightly. Press the key which closes the electric circuit. The two nails and the coil of wire act as an electromagnet. When the key makes contact, the circuit closes and the electromagnet attracts the T-sounder strip. When the key is released the circuit is open, releasing the power of the electromagnet. This causes the strip to be released. The time between clicks depends on how long the key is kept open.

Ways to Use the Telegraph Set

Use Morse Code to send messages.

Make up your own code.

Make two telegraph sets to send and receive messages.



Procedure:

Using two 1-1/2" nails, fasten one end of the larger wood block across the middle of the smaller one. Drill a 5/16" hole about 1" from the top and 1/2" from the edge of the mounting stand.

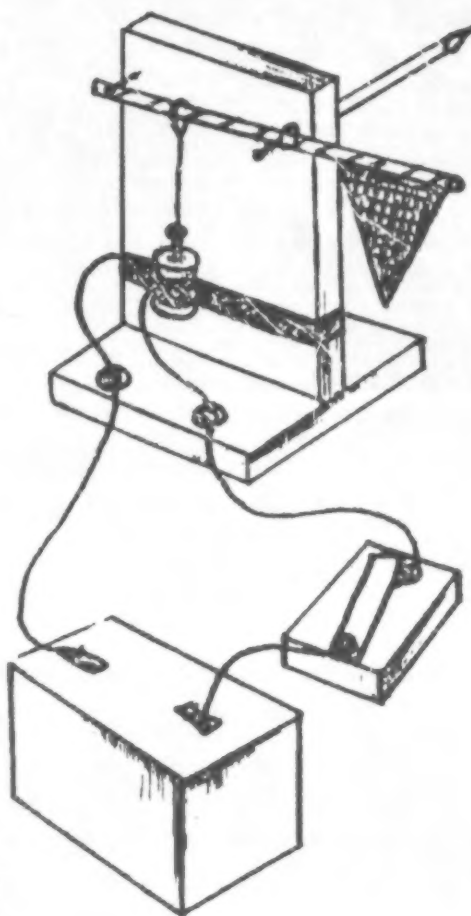
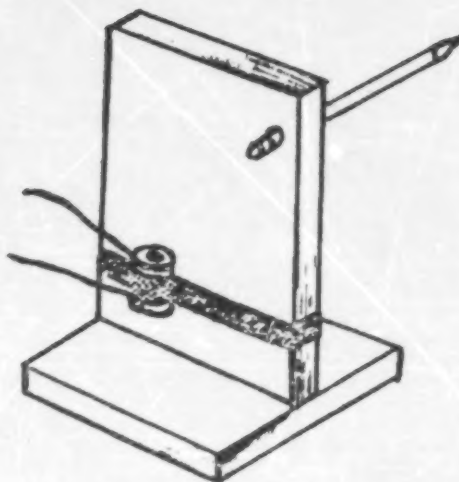
Wind about 300 layers of #28 magnet wire around the spool tightly and close together, removing all kinks before winding the wire in place. Leave about 8" sticking out at each end.

Use plastic electricians' tape or Scotch tape and fasten the spool of magnet wire 1" from the edge and about 1-1/2" from the bottom of the wood upright piece. Then cut the piece of cloth into a three corner flag and fasten the flag with Scotch tape or glue to the end of the soda straw pushing a straight pin through the soda straw into the eraser about 3-1/4" from the end opposite the flag. Work the soda straw up and down until the pin fits loosely.

Use a piece of string and tie the 1" nail near the end of the soda straw so that its point hangs just inside of the hole in the spool.

Keep the straw level by pushing the second pin in the wood upright just above the straw. Fasten the two round-head screws and washers to the baseboard of the mounting stand. Use a short piece of bell wire and connect the battery to the switch. Then scrape the insulation from the wires sticking out of the coil and connect each one to a round-head terminal screw on the baseboard. Use the bell wire to connect the remaining terminals on the battery and switch to the terminals on the baseboard.

Quickly close and open the switch several times. If things are in good working order, the nail moves in and out of the coil, causing the flag to wave up and down; if not, then change the distance between the flag end of the straw and the eraser. Push the pin through the straw at different points. Find one which works best. Nail point should hang just inside the center of the hole in the spool. Chewing gum can be placed on one end of the soda straw and to give balance needed for the flag to work.



ELECTRIC FLAG

This activity helps the student learn how to make a different kind of electro-magnet. This one is called a solenoid. It is called a "sucking coil" also, and can be used making an electric flag and hammer. It contains an iron core and coil of wire; however, the coil is always outside the core as the solenoid is the coil of wire carrying the current. The electrical current passes through the coil, then the iron core is sucked in. These are used to change electrical impulses by a pushing or pulling action. They are used in relays, contactors, and circuit breakers.

Materials:

